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Urban Junction Improvement by Implementation of Roundabout

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Abstract
The growth of traffic in the road network of large cities in developing countries like India is a serious concern. Bangalore being one of the most populated cities around the world where commuters either a two-wheeler or four- wheeler or both vehicles makes it bad for the traffic flow as everyone uses their own vehicle and so during peak hours there are severe long traffic congestions seen.

Long traffic congestions are seen at the Sankey tank road, even after widening the road and improvement of the existing at grade intersection there were severe traffic congestions because of the vehicles which travel from west to east of Bhashyam circle. These congestions are traffic signals and the bad traffic management. Due to this, several accidents are often observed at the signalized intersection as a result of drivers trying to beat the light, or jumping the signal.

To solve this traffic problem, a roundabout can be installed on this signal controlled at grade intersection, which will result in traffic accumulation on both sides of the interse ction, whereas if it is a roundabout, traffic will flow smoothly as converging vehicles will be forced to move around a large central island in one direction before weaving out of the traffic flow.
When compared to a signalised intersection, a roundabout not only delivers a smooth flow of traffic but also exhibits a significant reduction in conflict sites due to the unidirectional trafficflow. This eve ntually enhances the safety at the junction. In this report, we shall discuss about the design and implementation of roundabout on the intersections and the flow of traffic after the implementation.

INTRODUCTION

Road network is a very important aspect of transportation system as it connects even the smallest towns and cities. Emerging road traffic in medium and large cities is of major concern to developa network which would be able to satisfy the needs of traffic. The meeting area of two or more roads is called an intersection. Intersections are very important part of this network and are to be designed properly so as to handle the traffic efficiently.Un-signalised intersections help in free movement of traffic without any constraint while in case of signalized intersection there are certain constraints as to how the traffic flows. Un-signalized intersection has a drawback of large number of conflict points. As the number of lanes increase, the unrest at the intersection also increases drastically. The traffic movements like through, turning and crossing traffic are present at the intersection which lead to different conflicts. These conflicts may be handled in different ways depending on the type of intersection and its design. The safety, efficiency, speed, capacity and economy of a road depend upon the intersection design. Over the years, many reforms have been made to reduce this. Initially, the traffic at intersection was controlled by policemen. Then in later years, several other measures were carried out to ensure the free flow of traffic.

LITERATURE REVIEW

For achieving the requisite operational performance of a roundabout, the researchers focused on th e interaction between geometric design and traffic circumstances.

This chapter discusses the literature on operational analysis and design of roundabouts.

IRC:65-1976

(Recommended traffic rotaries practice) [1] by Indian Road

The design of traffic rotaries is guided by the guidelines established by Congress.

The recommendations for the design of' mini roundabouts' are not covered by the code.

According to the law, the rotary shall have a minimum traffic volume of 500 cars per hour and a maxi mum traffic volume of 3000 vehicles per hour.

The rotary's capacity is determined by both geometry and weaving traffic statistics.

The rotary has a speed limit of 40 kilometres per hour.

Separate pedestrian and bicycle crossings should be provided where needed.

Design manual for Roads and Bridges (TD 16/07) [2] i.e., the UK standards for roads lays down the guidelines for the design of roundabouts. The code gives recommendations for the selectionof type of roundabout like Mini, Normal, Compact, Grade Separated etc., geometric layout and visibility requirements depending on the design speed of approach roads and different type of traffic flow. According to code the widening localised at the point of entry is called entry flaring which helps in increasing capacity of the roundabout. Suggestions are given for the safety of different type of road users including large good vehicles, powered two wheelers and non-motorised users.

Design manual for Roads and Bridges (TD 54/07) [3] i.e., the UK standards for roads focuses onthe design standards and advice for the design of mini-roundabouts. It states that for the use of mini-roundabout the flow on any approach should be more than 500 vehicles per day. The designspeed of mini-roundabout should not exceed 30mph and the numbers of arms should be limitedto four. It gives suggestions for the geometric design features, the safety of mini-roundabouts anda flow chart for assessing mini-roundabout.

Federal Highway Administration of U.S. Department of Transportation (FHWA-SA- 10-007) [4] lays out technical summary for the planning, analysis, and design of mini- roundabouts. Itrecommends the total daily entering traffic should not exceed 15000 vehicles for a mini- roundabout and size of inscribed circle diameter should be less than 30m. Due to less maintenance of mini-roundabouts, they have longer service lives as compared to signalized intersections. It suggests benefit-cost analysis for programming purposes.

Satish Chandra and Rajat Rastogi (2012) [5] proposed a simple empirical method for determination of the entry capacity fi-om the flow conditions alone after comparing the results ofUK model, US method, German Model, Swiss model and Indian model. The capacity estimated by IRC model gave maximum value whereas US model gave minimum capacity for four selected roundabouts of Chandigarh city. The proposed method estimates roundabout capacity by considering circulating flow only and the result is comparable with German capacity model.

Alex Ariniello and Bart Przybyl (2011) [6] pointed out that the use of roundabouts instead of signalized intersection will result in fewer crashes and lower delay. It will also help in reducing greenhouse gas emissions and energy consumption. According to the study the crash rate can be reduced by 8.6% per year, energy consumption by 45,000 gallons of gasoline per year and emissions of CO2 by 400 metric tons per year. Considering safety benefits and significant reduction of emissions, roundabouts may be treated as an important sustainable measure of traffic control.

S. Anjana and M.V.L.R. Anjaneyulu (2014) [7] developed crash modification factors (CMFS) and Crash prediction models for the safety at roundabouts located in the state of Kerala. He tried to co-relate safety with geometric features of roundabout by developing models. He suggested that accident rates can be reduced by increasing circulatory roadway width, splitter island and exit angle.

Janet V Kennedy (2008) [8] proposed the UK standards for the geometric design of roundabouts and mini-roundabouts. The paper describes the important changes from previous versions. Non-motorised users are given more emphasis in the revised standard for roundabouts. According to TD 54/07 mini-roundabouts can be used as replacement junctions.

Edmund Waddell and James Albertson (2005) [9] explained the initial experience of America'sfirst mini-roundabout project. The Dimondale mini-roundabout helps in reducing vehicle emissions and fuel consumption it reduces 90,000 hours of delay. Comparing to raised island roundabouts cost is very much less for mini-roundabouts. The information will be helpful for the design of mini-roundabout in future.

Wei Zhang et al. (2013) [10] explained about the key features of mini-roundabout in the United States. The speed of the approaching roads must be lower (35mph) and total traffic entering from all connecting roads must be less than 1600 vehicle per hour. Lower bus and truck volumes help mini-roundabout to function adequately.

Taylor W.P. Lochrane et al. (2014) [11] gave recommendations for the design of mini- roundabouts from U.S. data and capacity models are analysed through simulation approach. The study concludes that mini-roundabout gives high capacity at lower cost as compared to single- lane roundabout. It also requires less space for the construction. For the quick estimation of capacity of mini-roundabout one model has been proposed in this paper.

Christian Bode and Faber Maunsell (2006) [12] identified some issues related to installation of mini-roimdabout. The paper investigates the issues related to the design of mini-roundabouts. Forthe effective use of mini-roundabout vehicle speed at entry should be 20 to 25mph and number ofarms should not exceed four. It suggests a minimum inscribed circle diameter of 12m.

Clive Sawers (2009) [13] pointed out the success and failures of mini-roundabouts in the U.K. He discussed about geometric design, general operation principles and safety at mini-roundabouts. He predicted that mini-roundabouts will be a popular junction type in the United States in next 25years.

Shruthi B and Ashuthosh Patel (2011) [14] have pointed out that roundabout reduces the accident rate by 40% in India and 76% in the USA. The main reason for the reduction is attributed to a slower speed and reduced number of conflicts. They also stated that the pedestrian safety is much improved in a roundabout as the vehicle-vehicle conflict points and vehicle to pedestrian conflict points has been reduced. And they also depicted that roundabout reduces the maintenance cost, reduction in delay, and improves the aesthetics of the intersection.

Vicky Gupta and Nayanna Bhosale(2018) [15] in their paper have discussed implementing a roundabout at a congested intersection to provide a smooth flow of traffic. They also stated that roundabout allows a smooth flow of 1800 vehicles per hour as per the experiment done in Detroit, USA. In their study they stated that the implementation of a roundabout shows a 37 % decline in overall collisions, a 75 % decline in injury collisions, a 90 % decline in fatality collisions, a 40% decline in pedestrian collisions. The paper also depicts the reason how roundabouts reduce the likelihood and severity of collision such as, no light to beat, low travel speed, one-directional travel.

Dodappaneni Abhigna, Sindhu Kondreddy and K. V. R. Ravi Shankar (2016) [16] in their literature state that, there are several methods to estimate the capacity of the roundabout, but most of them are for homogeneous lanebased traffic conditions and not applicable for mixed traffic conditions. This study tries to find out the applicability of the existing methods to mixed traffic conditions, identify the effect of vehicle composition, travel time and delay on capacity. It was observed that vehicle composition of the traffic influences the roundabout capacity and it is necessary to incorporate this factor into the existing capacity estimation models.

GAPS IN LITERATURE

- Guidelines for the design of roundabouts normally get revised in 10 to 15 years. ButIRC:65-1976 guidelines have not been revised since its first edition up until 2017.
- IRC:65-1976 also does not cover 'mini-roundabouts' which have already been tried inother countries.
- Some design parameters are not considered in IRC:65-1976 like inscribed circle diameter,entry flaring, skidding resistance etc.
- IRC:65-1976 always gives very high capacity than other standard models of differentcountries for the same set of data.

The present study aims at addressing these gaps by employing suitable guidelines for thedesign of a mini-roundabout intersections in the country.

METHODOLOGY

STUDY OF EXISTING INTERSECTION

1. Physical Geometry

The dimensions and layout of visible components of the roadway are dealt with by the physical geo metry of roadways.The physical geometry focuses on meeting the needs of the driver and the vehicl e, such as safety, comfort, and efficiency.The crosssection elements, sight distance consideration, ho rizontal curvature, gradients, and intersection are all factors that are usually taken into account.Driv er behaviour and psychology, vehicle attributes, and traffic parameters such as speed and volume all impact the design of these elements to a large extent.

Accidents and their severity can be reduced with proper physical geometric design. Therefore, the objective is to study the existing physical geometric design to provide sufficient basis for the simulation of the present scenario and to design the roundabout for the optimum safety and efficiency.

Data relating to some of the features to by studied under this section include:

- Design Speed
- Existing Topography
- Horizontal and Vertical alignment
- Width of carriageway, type and condition
- Radius of curves at intersection
- Width of turning lanes
- Visibility at the intersection
- Sight distances
- Traffic parameters
- Width of median
- Width of footpath/ shoulders
- Cross slope
- Clearance from fixed objects
- Right/left in driveway
- Road features and markings (Central and Ends)
- Utilities such as trees, transformers, wells, electric poles, telephone, etc.
- Drainage and availability of power and lighting
- Details of on-going road improvements, junction improvements, footpath improvement scheme, etc.

2. Traffic Parameters

Traffic volume count

It is essential to know the magnitude of traffic data required or to be collected, which will then determine its quality and type of vehicle classification to be adopted. Traffic counting falls in two main categories, namely; manual counts and automatic counts. There is no distinct difference between the two methods however, the economic use or selection of an appropriate method of traffic counting is a function of the level of traffic flow and the required data quality. This difference can be deduced from the discussions of the respective methods below, and in the subsequent chapters.

Manual Counts

The most common method of collecting traffic flow data is the manual method, which consist of assigning a person to record traffic as it passes. This method of data collection can be expensive in terms of manpower, but it is nonetheless necessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections. At intersection sites, the traffic on each arm should be counted and recorded separately for each movement. It is of paramount importance that traffic on roads with more than one lane are counted and classified by direction of traffic flow. Permanent traffic-counting teams are normallyset up to carry out the counting at the various locations throughout the road network at set interval. The duration of the count is determined prior to commencement of traffic counting andit is dictated by the end use of data.

Automatic Counts

The detection of vehicular presence and road occupancies has historically been performed primarily on or near the surface of the road. The exploitation of new electromagnetic spectra and wireless communication media in recent year, has allowed traffic detection to occur in a non- intrusive fashion, at locations above or to the side of the roadway.

The most commonly used detector types are:

i) Pneumatic tubes

These are tubes placed on the top of road surfaces at locations where traffic counting is required. As vehicles pass over the tube, the resulting compression sends a burst of air to an air switch, which can be installed in any type of traffic counting devices. Air switches can provide accurate axle counts even when compressions occur more than 30 m from the traffic counter. Although the life of the pneumatic tubes is traffic dependent as they directly drive over it, it is used worldwide for speed measurement and vehicle classification for any level of traffic. Care should be exercised in placing and operating thesystem, to ensure its efficient operation and minimize any potential error in the data.

ii) Weigh-in-Motion Sensor types

A variety of traffic sensors and loops are used world-wide to count, weigh and classify vehicles while in motion, and these are collectively known as Weigh In Motion (WIM) sensor systems. Whereas sensor pads can be used on their own traffic speed and axle weighing equipment, they are trigged by “leading” inductive loops placed before them on the roadbed. Some notable traffic sensors are:

- Bending Plates
- Capacitive Strip
- Capacitive Mat
- Piezo-electric Cable

A particular vicinity for counting site (everlasting or temporary) have to be decided on site. Where computerized counting device is to be used, the precise places of loops must be determined whilst taking cognisance of the ability use of statistics collected.

The following must be stored in thoughts earlier than choosing the counting site:

• The avenue segment must have uniform geometric traits alongside the street period and be far from junctions.

• Location must be on a horizontal (flat) and geometrically directly avenue segment.

• Section of the street to have an uninterrupted site visitors flow.

• Sections wherein phone strains or radio (mobile) are effortlessly reachable or may be installed, if possible.Delay at Signalized Intersection

Vehicle delay is the most important parameter used by transportation professionals in evaluating the performance of a signalized intersection. This is perhaps because it directly relates to the time loss that vehicles experience while crossing an intersection (though we have not considered other problems like congestion due to queuing, extra fuel loss due to vehicle ignition etc.). However, delay is a parameter that is not easily determined due to the non-deterministic nature of the arrivaland departure processes at the intersection. There are assumptions in the models used to define delay that help in simplifying the complex flow conditions to a quantifiable model which gives an approximate measure of average delay faced by a vehicle crossing an intersection. Some research tries to predict the variance of overall delay that individual vehicles may experience at signalized intersection due to large variation and randomness of traffic arrivals and interruption caused by traffic signal controls.

Measuring Delay at an Intersection

Delay at signalized intersection is computed as the difference in the departure time and the arrival time of a vehicle. It can also be said equal to the total extra time spent by a vehicle at the intersection than what is required if the vehicle were allowed to pass the intersection without any hindrance.
The total delay time can be categorized into deceleration delay, stopped delay and acceleration delay. The deceleration delay is the time loss that the vehicle takes in slowing down to reach to a stoppage, in case the signal is red or to a speed, in case there is a queue which is moving when the signal is green.
The stopped delay is the delay that the vehicle spends at the intersection while it is standing in a queue waiting for the signal to turn green. While most of the delay incurred at signalized intersections is directly caused by the traffic signal operation, a fraction of the total delay is due to the time required by individual drivers to react to changes in the signal display at the beginningof the green interval, to mechanical constraints, and to individual driver behavior.
When headway of the departing vehicles is observed it is seen that vehicles in front of queue take more time to cross a stationary point than the following vehicles and reach saturation headway after some point.
A final element that may affect the delays incurred at intersection approaches is the randomness in vehicle arrivals. If vehicles were to arrive at uniform intervals, the delays incurred by vehicles within successive signal cycles would be identical, as there would then be an exact replication of the arrival and departure patterns. In this case the flow at one intersection is independent of any other intersection upstream or downstream.

Finally, under random arrival patterns, the number of arrivals may fluctuate from one cycle to the other, thus resulting in different queue lengths. This may in turn result in arrival demands that occasionally exceed the approach capacity, and therefore, in higher delays.

Turning Movement Count

Turning movement counts, which represent the various approach movements (left, thru, right) that pass through an intersection over a given period of time, are collected for a variety of purposes at signalized and un-signalized intersections. In 2010, turning movement counts were collected by URS Corporation using the Video Collection Unit (VCU) developed by Miovision Technologies. The data was used to aid in a comprehensive traffic signal optimization study for Bashyam circle in Bangalore.

Common goals for traffic signal optimization studies include:

- Reduce fuel consumption and emissions
- Improve (reduce) vehicle travel times
- Standardize traffic signal operation parameters, including pedestrian crossing clearancetime updates
- Improve transportation safety for motoring public, pedestrians, and bicyclists

- Improve mobility without additional capital investment in road and bridge improvements

STUDY AREA

Indian being an assemblage of different cultures and customs, the behaviour of people varies extensively over the various parts of country. The development in terms of infrastructure in field of occupation, living environment and the transportation are also diverse. It can thus be summarized that the behaviour and composition of traffic along with road infrastructure is different in different parts of India. So, the question to select the appropriate site for the study of roundabouts arises.

Situated right opposite to what is left of the official palace grounds is now a home to many highly placed government officials, ex-governors, film stars and millionaire businessmen. The neighbourhoodis also home to various Wodeyar royals.

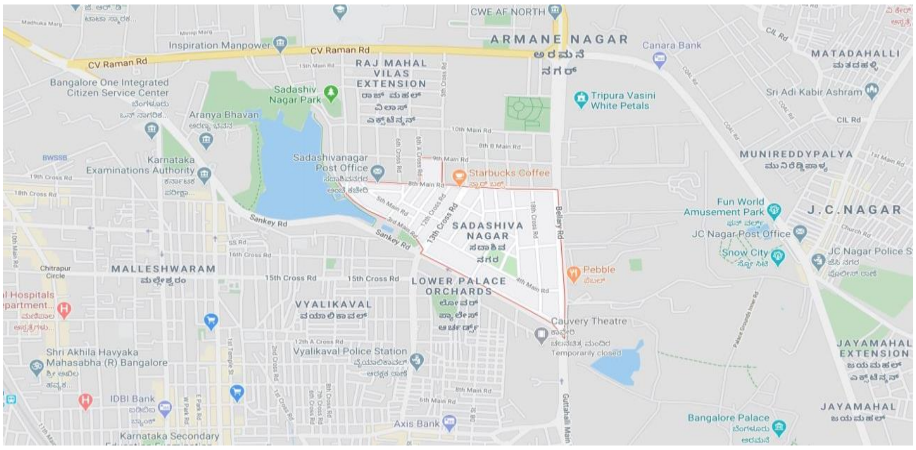
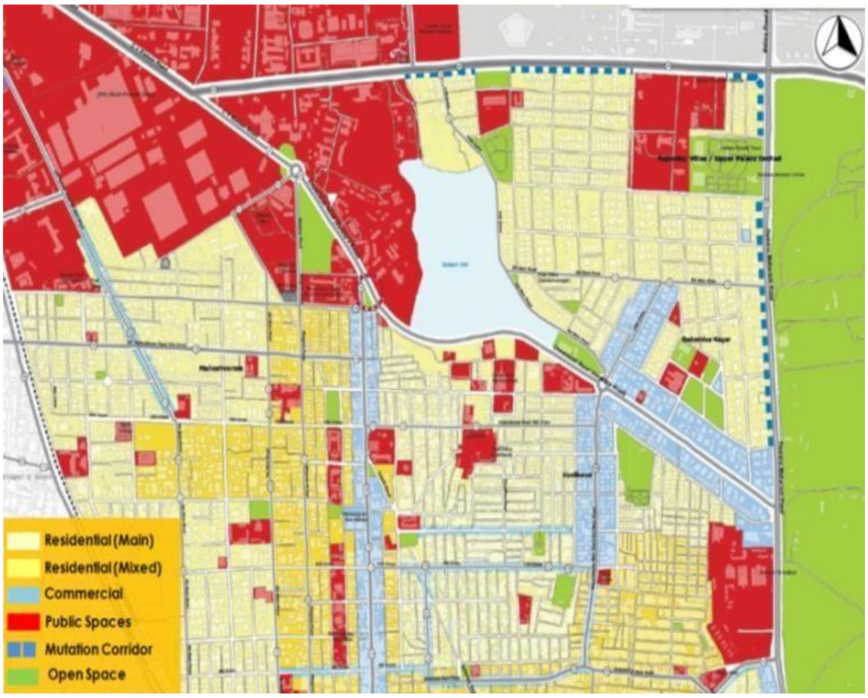


Fig 4.2.1: Study area- Sadhashiva nagar

Land Use

One of the important characteristics of roundabouts is to study and understand the land use pattern of the study area. Sadashivanagar is a well-established posh residential neighbourhood of



Bangalore. The land use is mainly of mixed residential type with public spaces such as Indian Institute of Science, the Raman Research Institute, Microsoft Research India, etc. to the north of the study area and an open space of Palace Ground to the east. Although the inner core of Sadashivanagar is mainly residential, the main arterial roads are attracting a lot of commercial activities.

Land Usage in Sadhashiva nagar

Roadway Segments and Intersections

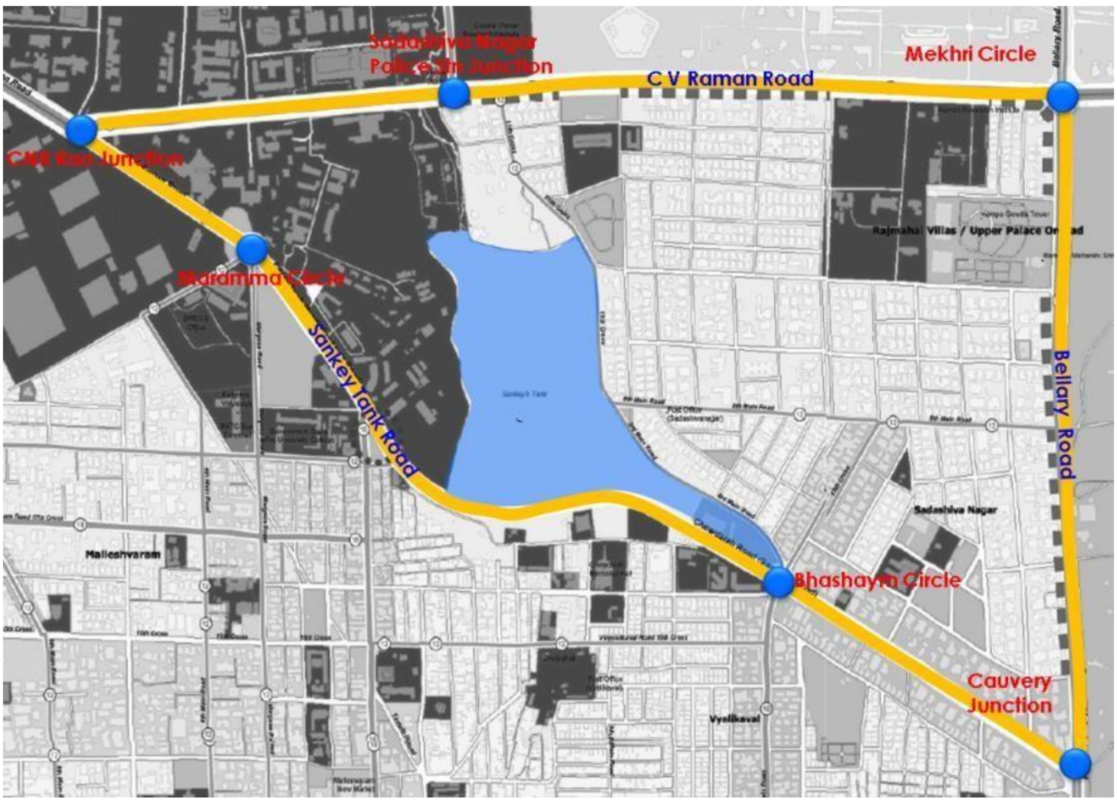
The study area Bashyam Circle is located around 3.5 km from the CBD of Bangalore, which connects to Cauvery Circle in the South-West and Sankey tank road along North-East, 13th cross road which leads to the residential colonies of Sadhashiva nagar and Gutthalli towards South.

Major Roadway Segments include:
The major roadway segments around the study area are:

- Sankey Tank Road (CNR Rao Circle–Cauvery Junction)
- C V Raman Road (Mekhri Circle- CNR Rao Circle)
- Bellary Road (Cauvery Junction-Mekhri Circle)

Major Intersection in study area:
The major intersections that are expected to impact the operational efficiency of the study area Bhashyam Circle (Sankey Road/13th Cross Road) are:

- CNR Rao Circle (Sankey Road/C V Raman Road)
- Sadashivanagar Police Station (C V Raman Road/New BEL Road)
- Mekhri Circle (Bellary Road/C V Raman Road)
- Cauvery Junction (Sankey Road/Bellary Road)



Major roadway segments and study intersection.

Surveys

Primary traffic surveys such as traffic volume counts, speed and delay surveys, road inventory survey, parking opinion Surveys & Bus passenger opinion and boarding and alighting survey were to be conducted during March- April 2020 in order to assess the traffic and transport scenario.

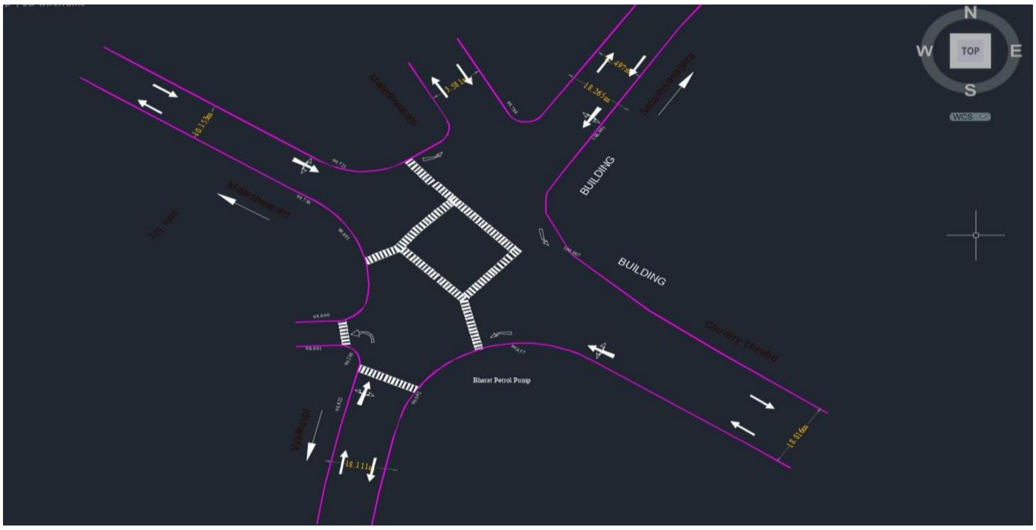


Fig 4.2.3.1: Existing signalised junction details

CONCLUSIONS

Due to enormous increase in the traffic in the recent times, most of the existing intersections have become congested and is viewed as a cause for major accidents and delays. Bangalore being one of the most populated city around the world experiences severe accidents and long traffic congestions on a regular basis.

To deal with these long traffic congestions and to satisfy the main aim, that is to reduces the possible conflict points at the study area Bhashyam Circle, the proposal of implementing a roundabout to replace the existing at grade signalised intersection brings in several benefits.

Numerous studies and researches shows the significant improvement and benefits of converting a signalised intersection into a roundabout intersection. Similarly, the present project also shows a certain improvement and benefits compared to a conventional signalised intersection such as:

- **Traffic safety:** The physical shape of roundabouts eliminates crossing conflicts that are present at conventional intersections, thus reducing the total number of potential conflict points and the most severe of those conflict points. The most comprehensive and recent study showed overall reductions of 37 percent in total crashes and 75 percent in injury crashes.
- **Pedestrian safety:** Additionally, the splitter island refuge area provides the ability for pedestrians to focus on one traffic stream at a time while crossing.
- **Traffic calming:** Roundabouts can have traffic calming effects on streets by reducing vehicle speeds using geometric design rather than relying solely on traffic control devices. And all the vehicles get equal opportunities.
- **Operational performance:** When operating within their capacity, roundabouts typically have lower overall delay than signalized and all-way stop-controlled intersections. The delay reduction is often most significant during non-peak traffic periods.
- **Environmental factors:** Roundabouts often provide environmental benefits by reducing vehicle delay and the number and duration of stops compared with signalized or all-way stop- controlled alternatives. Even when there are heavy volumes, vehicles continue to advance slowly in moving

queues rather than coming to a complete stop. This can reduce noise and air quality impacts and fuel consumption significantly by reducing the number of acceleration/deceleration cycles and the time spent idling.

- **Aesthetics:** The central island and splitter islands offer the opportunity to provide attractive entries or centerpieces to communities through use of landscaping, monuments, and art, provided that they are appropriate for the speed environment in which the roundabout is located.

There are several other papers and researches which claim that the introduction of a roundabout offers benefits like smooth flow of the traffic, vehicular and pedestrian safety and that a roundabout can handle higher capacities during the peak hours. The statement that the implementation of a roundabout can handle higher capacities during peak hours can be confirmed only after the designing and simulation using the data collected pertaining to the selected site as the scenario varies from one site to another.

But the main objective of reducing the possible conflict points at the selected at grade intersection by the implementation of a roundabout definitely meets the necessities.

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